RECENT SILICIC LAVA FLOWS ON OLYMPUS MONS? E. J. Rawling, K. L. Mitchell, L. Wilson and H. Pinkerton, Environmental Science Dept., Lancaster University, Lancaster LA1 4YQ, U.K. (*k.l.mitchell@lancaster.ac.uk*).

Introduction: We have used 160 MOC NA and several THEMIS VIS images to classify many volcanic flows on the flanks of Olympus Mons. Of particular note are long, narrow leveed flows, consistent with relatively high viscosity lava emplaced at high mass flux, probably supplied through laterally emplaced dykes. The negligible cratering in this area implies that these are among the youngest volcanic features on the planet.

Interpretation of parallel ridges: We interpret copious (many thousands) parallel-sided ridges (e.g. fig. 1) as being leveed volcanic flows, based on their positions and orientations (predominantly radial) relative to the summit, and by morphological similarity with terrestrial magmatic deposits. They range up to many hundreds of km in length, tens to a few hundred m in width and up to ~120 m in thickness. Occasional sinuous channels (sometimes with source depressions), interpreted as either being collapsed lava tubes or being due to thermal erosion, are interspersed with the leveed flows, with a slight tendency towards sinuous channels occupying higher elevations, possibly suggesting a causal relationship. Most leveed flows emanate from elevations at least 8 km (vertically) below the summit, but no clear sources have been identified. Many continue to the escarpment, but rarely do they continue more than a few kilometers beyond with the same morphology. In places the leveed flows appear to transform into more sheet-like flows or vice-versa (e.g. fig. 2), often with one sheet-like flow associated with many ridge pairs. The appearance of the leveed flows is similar to that of some pyroclastic flow deposits on the flanks of Mount St Helens, as well as blocky andesitic and dacitic lava flows, such as found on the flanks of Láscar volcano, Chile (fig. 3).

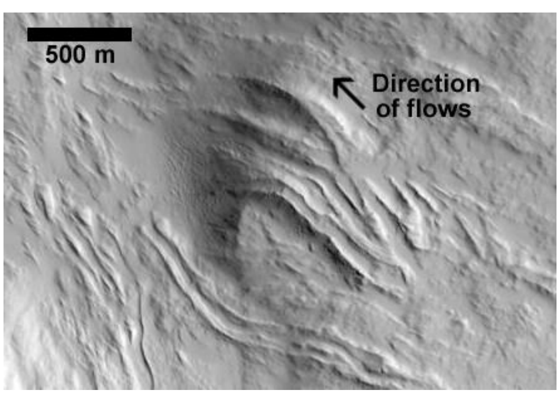

Fig. 1: Parallel ridges/leveed flows on Olympus Mons. MOC NA image m0401222.

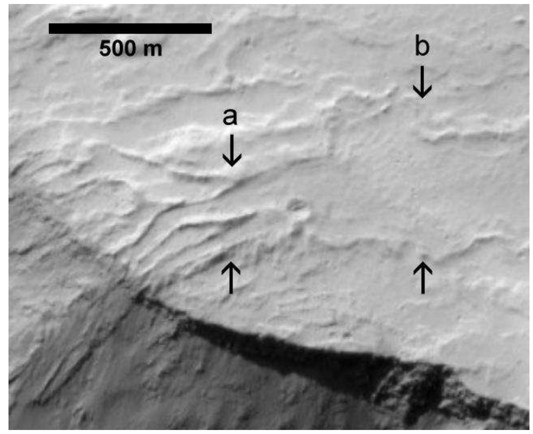

Fig. 2: Sheet-like flow (b) transforming into leveed flow (a). MOC NA image sp120803.


Fig. 3: Lava flows emanating from Lascar volcano, Chile (photographed by Peter Francis).

Pyroclastic flow deposits generally result from the collapse of an explosive eruption column, typically associated with high mass flux central vent eruptions on terrestrial volcanoes. Although such deposits need not start close to the vent, they are not known to have been emplaced at a significantly greater distance away from the vent than the height of the eruption column, as is observed at Olympus Mons. However, there is uncertainty as to the potential maximum height of erupting columns on Mars and, in addition, the explosivity of magmatic eruptions is enhanced due to Mars' lower atmospheric pressure and so flank eruptions may well result in highly explosive activity.

A pyroclastic flow model does not explain all of the morphological observations. Some of the individual levees exhibit a "double-ridged" appearance, and are much thicker (>50 m by shadow-length analysis) and steeper (up to 65°) than any observed on pyroclastic flows on the Earth, suggesting a cohesive strength inconsistent with unwelded material. Also some flows are nearly bank-full over most of their length suggesting deposition that does not appear to be consistent with pyroclastic flows in general. Finally, and perhaps most convincingly, some of these parallel ridges appear to feed into less ambiguous sheet-like lava flows.

Hence, we favour an interpretation as viscous lava flows. Such flows on the Earth are the result of more silicic (and hence viscous) mineralogies, typically andesitic or dacitic, than we expect on Mars (basaltic). Evolution, due to chemical differentiation, from basalt to andesite requires the presence of water in the magma chamber. If so on Mars, this could be indirect evidence that water remains present in mantle-melts [*cf.* 1].

Evolution beyond andesitic requires significant contamination of the magma chamber with recycled (high silica) materials, which is less likely than on the Earth due to the lack of plate tectonics. However, in the case of Olympus Mons it is plausible, as the magma chamber is predicted to lie above the level of the surface on which the volcano grew [2]. As a result, rising magma would have to pass through materials that were previously exposed to surface weathering. This also makes it possible that non-juvenile water could have been supplied to the magma chamber, and so our earlier case for the presence of mantle water is not unambiguous.

Long lava flows are generally associated with hot and less viscous lavas, such as basalts. However, long lava flows are also compatible with more silicic magmas if effusion rates are large [3]. This would be consistent with Martian volcanism, due to the greater depths of magma chambers and hence larger predicted dyke widths, and hence supply rates.

Distribution of flows: Our interpretation that the parallel-sided ridges are viscous lava flows supports suggestions [4] that the flanks of Olympus Mons are characterized by channelised lava flows with morphologies similar to `a`a, overlapping and branching to produce an overall "feathery" texture, that can transform into sheet-like flows when they reach the shallower slopes of the surrounding plains. In terms of gross morphology, this is similar to that found on many terrestrial strato-volcanoes (typically andesitic to dacitic, and composite in origin), including Láscar (Chile), and Arenal (Costa Rica).

The flows cannot be traced to the summit, implying that they erupt from (undetected) vents part way down the flanks of the volcano. This would be consistent with a models [5] suggesting that dykes should preferentially propagate laterally, rather than vertically. If eruptions were fed through such dykes, they could be driven by the overlying weight of the magma, hence allowing much more voluminous flows than possible through vertical conduits.

Timing of activity: The underlying terrain is of extreme Upper Amazonian age (no precise crater counting has yet been performed), and so these features are possibly the youngest products of volcanism on Mars, comparable with late-stage activity at Cerberus Fossae (< 200 Ma; [6]).

Following a global survey, we cautiously interpret only a handful of possibly similar features on Ascraeus Mons, Elysium Mons and east of Apollinaris Patera as being similar in origin – in no cases are they as well preserved or as copious as those on Olympus Mons.

The lack of similar features on other volcanoes may be because they are representative of a style of activity that is rare elsewhere, possibly due to this being late stage volcanism for Mars, or because they are heavily degraded due to relative age or greater erosion rates.

Wilson et al. [7] pointed out that the mean magma volume supply rate at which the Tharsis volcanoes were constructed is much less than the minimum rate that allows magmas to rise from the mantle without excessive cooling. They deduced that the Tharsis volcanoes were built episodically with active phases lasting less that 1 Ma, alternating with ~100 Ma quite phases.

Independent mantle modeling work [8] also suggests a 100 Ma cycle for the generation of mantle plumes, that can be sustained at sublithospheric hotspots over time scales of several hundred Ma. This model has been used to explain the persistent and focused volcanism in the Tharsis region, and also predicts that this pulsating mantle plume may yet recur.

If these flows are confirmed to be of the order of 100 Ma or less, it is plausible that Olympus Mons may become active again in the future. However, it is unlikely that we shall observe this on the scale of the human lifetime unless we happen to be in a period of activity now, which seems unlikely.

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